

Airborne Measurements of Tropospheric Ozone Destruction and Particulate Bromide Formation in the Arctic

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Aircraft profiles of O_3 concentrations over the Arctic ice pack in spring exhibit a depletion of O_3 beneath the surface temperature inversion. One such profile from the NOAA WP-3D Arctic Gas and Aerosol Sampling Program (AGASP) flights in April, 1986 north of Alert, NWT (YLT, $82.5^\circ N$) is shown in Figure 1. The gradient of O_3 across the temperature inversion, which is essentially a step function from tropospheric values (35-40 ppbv) to 0, is somewhat masked by a 1-minute running mean applied to the data.

Barrie et al. (1988) have presented evidence that O_3 destruction beneath the Arctic temperature inversion is the result of a photochemical reaction between gaseous Br compounds and O_3 to produce particulate Br aerosol. They note that in springtime, O_3 at the Alert Baseline Station regularly decreases from 30-40 ppbv to near 0 over the period of a few hours to a day. At the same time, there is a production of particulate Br with a near 1.0 anti-correlation to O_3 concentration. Surface concentrations of bromoform in the Arctic exhibit a rapid decrease following polar sunrise (Cicerone et al., 1988).

AGASP aircraft measurements of filterable bromine particulates in the Arctic (March-April, 1983 and 1986) are shown in Figure 2. The greatest concentrations of Br aerosol (shown as enrichment factors relative to Na in seawater, EF_{BR} (Na)) were observed in samples collected beneath the surface temperature inversion over ice. Samples collected at the same altitude over open ocean (off Spitzbergen) labeled "Marine" did not exhibit similar Br enrichments.

A second region of particulate Br enrichment was observed in the lower stratosphere, which regularly descends to below 500 mb (5.5 km) in the high Arctic. The NOAA WP-3D flew in the stratosphere on all AGASP flights and occasionally measured O_3 concentrations in excess of 300 ppbv.

AGASP aircraft gas flask measurements (Berg et al., 1984) show that both bromoform and methylene bromide concentrations decrease with altitude in the troposphere but increase in the lower stratosphere as shown in Figure 3. Bromoform and methylene bromide over the ocean (symbol M) do not exhibit higher concentrations beneath the temperature inversion as they do over ice.

It is yet to be determined if any relationship exists between the relatively high concentrations of bromine gases in the stratosphere and the associated elevated bromide concentrations. If the same tropospheric bromine-ozone photochemistry were to occur in the lower stratosphere as in the troposphere, one might speculate that stratospheric ozone is being similarly eroded at its lower boundary.

References

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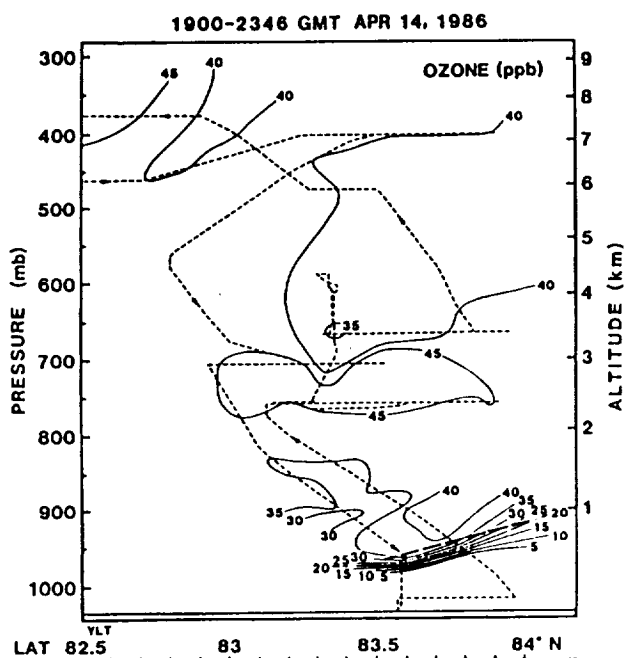


Figure 1. Cross-section of ozone concentrations upwind of Alert, NWT (82.5°N) on April 14, 1986. The thick-dashed line indicates the base of the surface temperature inversion and the thin-dashed lines plot the aircraft flight track. The depleted ozone below the surface temperature inversion is evident.

AIRCRAFT FILTER DATA FROM THE 1983 AND 1986 AGASP MISSIONS BROMINATED ORGANIC SPECIES IN THE ARCTIC ATMOSPHERE

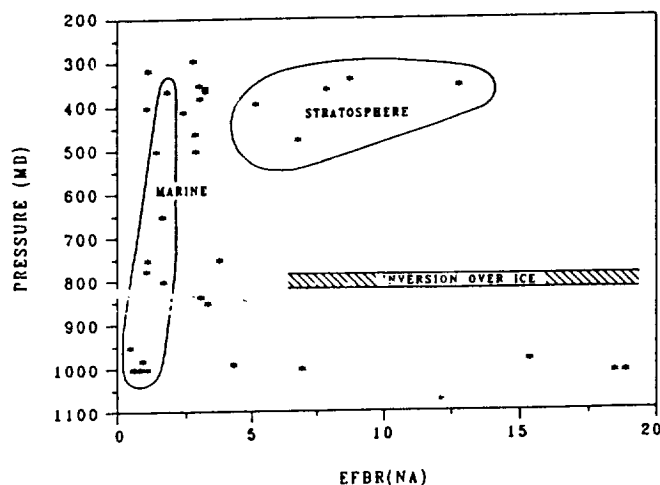


Figure 2. Aerosol filter data from the Arctic showing enrichments of filterable bromine relative to seawater. High concentrations of bromide particulates were present over ice beneath the surface temperature inversion and in the lower stratosphere. There were no bromide enrichments over the open ocean (MARINE) at any altitude.

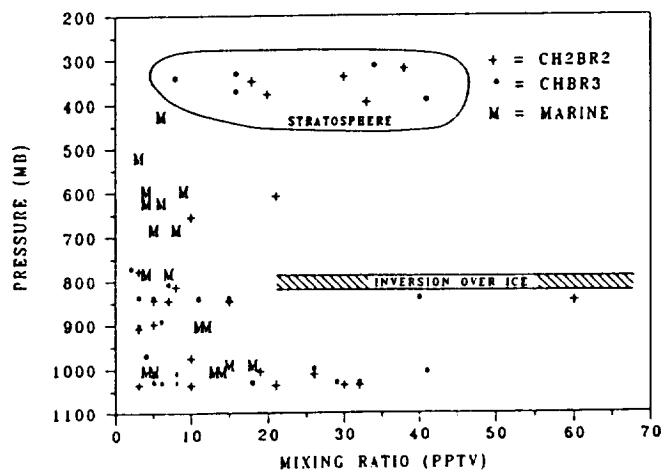


Figure 3. Concentrations of the gases bromoform (CHBr_3) and methylene bromide (CH_2Br_2) in the high Arctic. Samples indicated by M were collected over the open ocean. Higher gas concentrations in the lower troposphere and the lower stratosphere are in evidence.